CALIFORNIA DEPARTMENT OF CONSERVATION
DIVISION OF MINES AND GEOLOGY

FAULT EVALUATION REPORT FER-223
FAULTS OF THE WESTERN WARNER MOUNTAINS, LASSEN AND MODOC COUNTIES, CALIFORNIA

by

William A. Bryant
Associate Geologist
November 26, 1990

Division of Mines and Geology
630 Bercut Drive
Sacramento, CA 95814

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INTRODUCTION

Potentially active faults in the Western Warner Mountains study area of eastern Modoc County and northeastern Lassen County that are evaluated in this Fault Evaluation Report (FER) include faults that comprise the Goose Lake fault, the Davis Creek, Fitzhugh Creek, Jess Valley, and related fault zones (Figure 1). With the exception of the Goose Lake fault, none of the faults evaluated in this FER have previously been named. New names are proposed in this FER. The Western Warner Mountains study area is located in parts of the Willow Ranch and Davis Creek 15-minute quadrangles and the Dorris Reservoir, Jess Valley, Little Juniper Reservoir, Shields Creek, Soup Creek, and Tule Mountain 7.5-minute quadrangles (Figure 1).

Faults in the Western Warner Mountains study area are evaluated as part of a statewide effort to evaluate faults for recency of activity. Those faults determined to be sufficiently active (Holocene) and well-defined are zoned by the State Geologist as directed by the Alquist-Priolo Special Studies Zones Act of 1972 (Hart, 1988).

This fault evaluation consists of literature review and reconnaissance aerial photographic interpretation only. Time limitations precluded a thorough study of the area with respect to both detailed air photo interpretation and field observations. Faults that occur west of Highway 395 in this study area are evaluated in FER-221.

SUMMARY OF AVAILABLE DATA

The Western Warner Mountains study area is located in the Modoc Plateau geomorphic province. The Modoc Plateau is characterized by extensive volcanic rocks of late Tertiary and Quaternary age displaced by many north to northwest-trending normal faults. East-west directed extension characterizes the most recent stress regime in the study area, which has resulted in north-trending normal faults.

Topography in the study area ranges from the flat surface of Goose Lake to the moderately rugged relief of the western slope of the Warner Mountains. Elevations in the study area range from 1341 meters in the North Fork Pit River floodplain to greater than 2600 meters along the crest of the Warner Mountains. Development in the study area is relatively low. The town of Alturas is the largest settlement and is located just west of the study area. Agriculture (farming and cattle grazing) is the principal activity in the study area.

Rocks in the study area are predominantly volcanic flow and pyroclastic rocks of late Tertiary to Pleistocene age (Gay and Aune, 1958; CDWR, 1963; Lydon, 1969). Quaternary deposits include Pleistocene and Holocene fluvial deposits in the Pit River drainage, Pleistocene and Holocene (?) alluvium in several small basins along the Fitzhugh Creek fault, and Pleistocene and Holocene lacustrine and alluvial deposits in the Goose Lake and Jess Valley areas.

Mapping by Gay and Aune (1958; unpublished field maps), CDWR (1963), and Lydon (1969) will be evaluated in this FER. The majority of mapping of faults in the Western Warner Mountains study area has been reconnaissance in nature and is reflected by the relatively small scale (range from 1:62,500 to 1:250,000 of available topographic maps).

Aerial photographic interpretation by this writer of faults in the Western Warner Mountains study area was accomplished using aerial photographs from the U.S. Department of Agriculture (BUW, 1955). In addition, small scale U.S. Geological Survey photos (VVHU, 1953) were used to provide a more regional perspective in the study area. Selected fault traces interpreted from aerial photographs by this writer were mapped where geomorphic features were well-defined or where faults mapped by others seemed to be mislocated due to the small scale of the original mapping.

GOOSE LAKE FAULT

Literature Review

The Goose Lake fault is an approximately 24 km long, north-trending normal fault (Figures 1, 2a). The fault is characterized by an unknown amount of down-to-the-west vertical displacement.

The fault was first mapped by Gay and Aune (1958), who depicted the fault as concealed by late Quaternary alluvium along the western side of the Warner Mountains (Figure 2a). The fault bends to the east along the northern side of Fandango Pass where Gay and Aune mapped offset late Quaternary alluvium (locality 1, Figure 2a). However, the nature of the offset or lack of offset is somewhat obscured by the fact that the fault is shown as dashed along most of its trace (Figure 2a). C. Jennings (p.c., 1990) stated that faults shown as dashed lines on the 1958 Alturas Sheet actually were intended to be depicted as concealed. It is uncertain what the intention was at locality 2 (Figure 2a), where the fault is dashed through Tertiary volcanic rocks. Subsequently, Jennings' 1975 fault map showed the fault as concealed by alluvium along the range front, rather than extending into the range front at locality 2. Also, Gay and Aune's field maps (not plotted on Figure 2a) indicate that the fault is located at the range front boundary, rather than concealed by Tertiary volcanic bedrock.

The Goose Lake fault mapped by CDWR (1963) consists of several generally north-trending strands along the range front that are concealed by late Pleistocene and Holocene alluvium (Figure 2a). The fault differs from the trace mapped by Gay and Aune along its northern trend, where multiple, concealed strands are mapped. The southern part of the Goose Lake fault (the northwest-trending strand) is similar to the trace mapped by Gay and Aune. A significant difference is that CDWR does not map the fault as offsetting late Quaternary alluvium at locality 1 (Figure 2a).

The Goose Lake fault mapped by Lydon (1969-unpublished field map) generally is located along the base of the range front along the east side of Goose Lake (Figure 2a). The fault is concealed by late Quaternary alluvium along most of its trace. A small section of the fault is mapped as offsetting bedrock in sec 25, T47N, R20E (Figure 2a). Lydon mapped a short, northwest-trending fault along the southern side of Fandango Valley as offsetting late Quaternary alluvium (locality 3, Figure 2a).

Lydon mapped a fault concealed by Holocene alluvium (lacustrine deposits) south of Willow Ranch (locality 4, Figure 2a). This fault may be a right-step segment of the Goose Lake fault. The concealed trace is located at the base of the west-facing escarpment along the southeastern side of Goose Lake. No other workers mapped a fault at this location.

Aerial Photographic Interpretation

The Goose Lake fault is moderately defined by faceted spurs and a break in slope at the range front (Figure 2a). Mapping by Gay and Aune, CDWR, and Lydon generally was not verified by this writer, although the mapping of Lydon may be the most reasonable interpretation (trace concealed by late Pleistocene to Holocene alluvium).

The fault generally lacks specific geomorphic features indicative of Holocene normal faulting, such as scarps in alluvial fans, vertically offset or "wineglass"-shaped drainages, and troughs or graben along the base of scarps. The absence of terraces along the Pine Creek drainage suggests that the range front has not undergone significant uplift during in the past 10,000 years (locality 5, Figure 2a). The relative sinuosity of the range front also suggests a lack of significant recent uplift.

The alluvial fan at Badger Canyon seems to be offset, indicated by a break-in-slope in the fan (locality 6, Figure 2a). This break-in-slope is associated with scarps in bedrock along the range front to the south. However, the bedrock scarp may have been produced by lateral stream erosion, because it is best defined adjacent to the apex of the alluvial fan at Badger Canyon. Badger Canyon is the only location along the Goose Lake fault where an alluvial fan appears to be displaced. Fan-head entrenchment was observed in Cloud Canyon, the next drainage to the south, although a clearly offset alluvial fan was not observed.

Traces of the Goose Lake fault south of Barnes Creek to the Willow Creek drainage are obscured by landslides (Figure 2a). The Goose Lake fault in Fandango Valley is poorly defined and is concealed by late Pleistocene and Holocene alluvial/colluvial deposits. Faults offsetting late Quaternary alluvium mapped by Gay and Aune (locality 1) and Lydon (locality 3) were not verified.

Geomorphic evidence of recent faulting was not observed along the southern Goose Lake fault mapped by Lydon (south of Willow Ranch)(Figure 2a).

DAVIS CREEK FAULT ZONE

Literature Review

An approximately 4 km wide, northwest-trending fault zone in the vicinity of Davis Creek is informally referred to in this FER as the Davis Creek fault zone (Figures 2a and 2b). The style and amount of displacement is not know. The fault zone, which consists of up to 5 sub-parallel traces in bedrock, extends for about 20 km. The fault zone has been mapped by Gay and Aune (1958) and CDWR (1963). The northern end of the fault zone was also mapped by Lydon (1969).

The fault zone mapped by Gay and Aune generally offsets late Tertiary volcanic bedrock. However, one trace of the Davis Creek fault zone offsets Holocene (?) lake deposits at locality 7 (Figure 2a).

CDWR (1963) mapped the Davis Creek fault similar to traces mapped by Gay and Aune, although CDWR mapped several additional strands to the west (Figure 2a, 2b). Significantly, CDWR did not map offset Holocene lacustrine deposits at locality 7 (Figure 2a). The Davis Creek fault zone mapped by CDWR offsets late Tertiary bedrock, but locally is concealed by Pleistocene "near shore" deposits.

Lydon (1969) mapped strands of the northern extent of the Davis Creek fault zone (Figure 2a). The location of the fault in Mulkey Canyon agrees well with traces mapped by Gay and Aune and CDWR (locality 8, Figure 2a). Faults east of Mulkey Canyon mapped by Lydon offset late Tertiary bedrock, but do not offset late Pleistocene to Holocene alluvial deposits. Lydon did not map the fault as offsetting Holocene lacustrine deposits at locality 7.

Aerial Photographic Interpretation

The Davis Creek fault zone consists of a broad, northwest-trending zone of moderately defined faults in bedrock (Figures 2a and 2b). Geomorphic evidence of latest Pleistocene to Holocene displacement was not observed.

Geomorphic features indicative of Quaternary right-lateral strike-slip displacement along strands of the Davis Creek fault zone include linear drainages, right-laterally deflected drainages, ponded alluvium, and troughs in bedrock (Figures 2a and 2b). Individual strands of the Davis Creek fault zone lack geomorphic evidence of systematic right-lateral and normal offset. Although some drainages are right-laterally deflected, most drainages crossing traces of the fault zone are not offset or deflected.

An older Pleistocene alluvial unit is offset immediately north of North Fork Davis Creek (locality 9, Figure 2b). The scarp, which is back-facing, is rounded and degraded and lacks geomorphic evidence of Holocene displacement. The fault strand that offsets lake deposits mapped by Gay and Aune at the northern end of Mulkey Canyon was not verified by this writer (locality 7, Figure 2a). There is a short, vague tonal lineament in what is presumed to be a Pleistocene wave-cut platform.

FITZHUGH CREEK FAULT ZONE

Literature Review

A 30 km long, north-trending zone of normal faults characterized by down-to-the-west vertical displacement will be informally referred to in this FER as the Fitzhugh Creek fault zone (Figures 1, 2b, 2c and 2d). The amount of displacement along the Fitzhugh Creek fault is not known.

The Fitzhugh Creek fault zone was first mapped by Gay and Aune (1958). They mapped the fault zone as locally offsetting Pliocene volcanic rocks against Pleistocene volcanic rocks (Figure 2c). The Pleistocene volcanic rocks mapped by Gay and Aune have since been shown to be late Miocene to Pliocene in age and designated as the basalt of Devils Garden by McKee and others (1983). Gay and Aune mapped the Fitzhugh Creek fault as a series of right-stepping en echelon north-trending faults (Figure 1).

CDWR (1963) mapped the Fitzhugh Creek fault similar to Gay and Aune, although differences in detail exist (Figures 2c and 2d). Generally, the fault zone is concealed by late Pleistocene and Holocene alluvial deposits. Several basins filled with alluvium occur on the downthrown side of individual fault strands, juxtaposing latest Pleistocene alluvium against bedrock (localities 10, 13, and 17, Figure 2c). The southern end of the Fitzhugh Creek fault extends across the South Fork Pit River and is concealed by Holocene alluvial deposits (terrace deposits) (locality 11, Figure 2d).

Aerial Photographic Interpretation

Strands of the Fitzhugh Creek fault zone are locally well-defined in resistant volcanic bedrock. Traces mapped by CDWR (1963) were generally verified by this writer with respect to location in Tertiary bedrock (Figures 2c and 2d). Geomorphic evidence of latest Pleistocene to Holocene displacement was not observed. Drainages cut into resistant basalt are not offset across strands of the Fitzhugh Creek fault zone (localities 12 - 15, Figure 2c). Significantly, Fitzhugh Creek is not offset across two strands of the fault zone (localities 13 and 14, Figure 2c). A right-laterally deflected drainage at locality 12 is probably joint-controlled; there is no systematic right-lateral deflection of drainages along the Fitzhugh Creek fault zone. An eroded alluvial fan presumed to be Pleistocene is not offset along the northern strand of the fault zone (locality 16, Figure 2c). Also, an eroded fan is not offset along the south-central strand at locality 17 (Figure 2c).

JESS VALLEY FAULT

Literature Review

The Jess Valley fault is an approximately 32 km long normal fault with an unknown amount of down-to-the-east vertical displacement (Figures 2c and 2d). The fault generally treads north, but is arcuate (concave to the east) in the vicinity of Jess Valley. The fault previously was not named; it is informally named in this FER.

Gay and Aune (1958) mapped the fault as offsetting late Tertiary volcanic bedrock (Figures 2c and 2d). The alluvial/lacustrine deposits in Jess Valley are not offset by the fault (fault here was mapped as a dashed line, which is interpreted to represent a concealed fault).

CDWR (1963) mapped strands of the Jess Valley fault that offset late Tertiary volcanic bedrock (Figures 2c and 2d). The fault mapped by CDWR is concealed by Holocene alluvium at the southern end of Jess Valley (Figure 2c). CDWR did not map a fault at the base of the slope in Jess Valley.

They mapped the main trace of the fault farther east in bedrock near the top of the slope west of the fault mapped by Gay and Aune (Figure 2d). The Jess Valley fault is more complex than mapped by Gay and Aune and consists of several traces west of the main trace.

Aerial Photographic Interpretation

The Jess Valley fault is delineated by an east-facing scarp in volcanic bedrock. The fault is moderately defined and lacks geomorphic evidence of latest Pleistocene to Holocene displacement. Mapping by CDWR in Jess Valley was not verified by this writer (Figures 2c and 2d).

A scarp in bedrock near the base of the east-facing slope in Jess Valley lacks geomorphic evidence of recent faulting. Alluvium and lacustrine deposits at one time ponded against the bedrock escarpment, but the drainage has since cut through the bedrock (locality 18, Figure 2d). There is no evidence of a scarp or tonal lineament in the alluvium at this location. Alluvial fans south of the North Fork Pit River are not offset by the Jess Valley fault (localities 19 and 20, Figure 2d).

A large landslide in the drainage of the North Fork Pit River probably caused the latest ponding of alluvium in Jess Valley (locality 21, Figure 2d). Additional landslides along the Jess Valley fault are located south of Jess Valley to near Blue Lake (locality 22, Figure 2d). Blue Lake is a landslide-dammed lake.

ADDITIONAL FAULTS IN STUDY AREA

Additional unnamed faults were mapped by CDWR (1963) between the Goose Lake and Davis Creek fault zones, between the Fitzhugh Creek and Jess Valley fault zones, and west of the Fitzhugh Creek fault zone (Figures 2a-2d). These unnamed faults generally are not well-defined and lack geomorphic evidence of latest Pleistocene to Holocene normal or normal oblique displacement.

SEISMICITY

The study area is characterized by a paucity of seismic activity. A and B quality epicenters in the Western Warner Mountains study area have not been recorded (CIT, 1985) and only a few epicenter locations of lesser quality have been recorded. One event of magnitude 3.0 to 4.4 occurred about 5 km north of West Valley Reservoir and may be associated with the Fitzhugh Creek fault zone (Figure 2c). An earthquake in the M 3.0 - 4.4 range occurred about 5 km south of Blue Lake and may be associated with the Jess Valley fault (Figure 2d).

CONCLUSIONS

GOOSE LAKE FAULT

The Goose Lake fault, an approximately 24 km long north-trending normal fault (down to the west), was mapped as a concealed fault by Gay and Aune (1958), CDWR (1963), and Lydon (1969) (Figure 2a). Geomorphic evidence of latest Pleistocene to Holocene normal faulting was not observed along the Goose Lake fault, based on air photo interpretation by this writer (Figure 2a). The fault lacks specific geomorphic features indicative of Holocene normal faulting such as scarps in alluvial fans, vertically offset or "wineglass-shaped" drainages, and troughs or graben along the base of scarps. However, the fault is delineated by geomorphic features indicative of late Quaternary normal faulting such as faceted bedrock spurs, a break-in-slope at the base of the range front, and a possible scarp (or break-in-slope) in an alluvial fan at locality 6 (Figure 2a). This possible scarp or break-in-slope is not well-defined and should be field checked to verify the air photo interpretation. The proximity to the apex of the alluvial fan suggests that the scarp may be erosional. The lack of additional scarps in alluvial fans, the lack of terraces along the Pine Creek drainage, and the generally sinuous range front indicate a lack of significant Holocene uplift.

It is possible that the faceted spurs and possible scarp in alluvium are the result of wave erosion associated with Pleistocene Goose Lake. The lacustrine history of Goose Lake has not been studied in detail. The current lake elevation is at 1432 meters. The lake outlet is located to the south along the North Fork of the Pit River and is currently at elevation 1437 meters (CDWR, 1963). A narrow drainage was incised through bedrock along the Pit River during the Pleistocene, perhaps as recently as the Wisconsin (early to mid-(?)) glacial stage.

The morphology of the drainage channel seems to preclude significant downcutting during latest Pleistocene to Holocene time, based on the relatively flat-floored shape of the North Fork Pit River drainage and lack of incision of the alluvial fill, the relatively rounded crests of the western drainage (through the Devils Garden basalt), and the presence of tributary drainages that have well-established channels. It seems unlikely that these tributary drainages would have cut down to base level if the principal channel had been cut during the last 13,000 years. Because of these factors, it seems unlikely that lacustrine processes (wave-cut benches and scarps) have modified the western slope of the Warner Mountains in the vicinity of Goose Lake. Therefore, it is possible that a minor amount of latest Pleistocene to Holocene displacement has occurred along the Goose Lake fault. However, the lack of geomorphic evidence of systematic vertical displacement indicates that zoning is not warranted at this time.

DAVIS CREEK FAULT

The Davis Creek fault is an approximately 4 km wide, northwest-trending zone of presumably right-lateral strike-slip faults with a component of normal displacement (Figures 2a and 2b). The fault zone consists of up to 5 sub-parallel traces with a total fault length of about 20 km. Traces mapped by Gay and Aune (1958), CDWR (1963), and Lydon (1969) (northern extent) were verified with respect to location by this writer, based on air photo interpretation. The fault zone is characterized by geomorphic features indicative of Quaternary right-lateral displacement, such as linear drainages, ponded alluvium, troughs in bedrock, and, locally, right-laterally deflected drainages. However, latest Pleistocene to Holocene displacement was not observed. Individual strands of the Davis Creek fault zone lack geomorphic evidence of systematic right-lateral and normal offset. Most drainages developed in bedrock that cross fault traces are not offset or deflected.

The offset Holocene lacustrine deposits mapped by Gay and Aune (1958) at locality 7 (Figure 2a) were not mapped by CDWR (1963) or Lydon (1969). The fault was not verified by this writer. However, a short, vague tonal lineament 1.5 km southeast of locality 7 was observed by this writer, based on air photo interpretation. It is not certain if this feature is located in lacustrine deposits or a Pleistocene wave-cut platform in bedrock. It is possible that the feature is artificial.

FITZHUGH CREEK FAULT ZONE

The Fitzhugh Creek fault is a north-trending zone of normal faults with an unknown amount of down-to-the-west vertical displacement (Figures 2b, 2c, and 2d). Traces of the Fitzhugh fault zone are delineated by moderately well-defined to locally well-defined scarps in resistant late Tertiary volcanic bedrock. Geomorphic evidence of latest Pleistocene to Holocene normal faulting was not observed by this writer, based on air photo interpretation. Drainages cut into resistant bedrock are not offset (localities 12 -15) and eroded alluvial fans of probable Pleistocene age are not offset (localities 16 and 17, Figure 2c).

JESS VALLEY FAULT

The Jess Valley fault is an approximately 32 km long, north-trending normal fault with down-to-the-east vertical displacement (Figures 2c and 2d). The fault is moderately defined to locally moderately well-defined and lacks geomorphic evidence of latest Pleistocene to Holocene offset. Alluvium of probable Pleistocene age was ponded against the east-facing scarp in Tertiary volcanic rock at locality 18 (Figure 2d). There is no scarp or tonal lineament in the recent alluvium and the drainage channel incised in resistant volcanic bedrock lacks evidence of recent uplift. Alluvial fans south of locality 18 are not offset and the southern part of the Jess Valley fault has been modified or obscured by lateral stream erosion or landslides (Figure 2d).

ADDITIONAL FAULTS IN STUDY AREA

Additional faults in the Western Warner Mountains study area mapped by Gay and Aune (1958), CDWR (1963), and Lydon (1969) were not verified as well-defined normal faults with latest Pleistocene to Holocene offset, based on reconnaissance air photo interpretation by this writer (Figures 2a - 2d).

RECOMMENDATIONS

Recommendations for zoning faults for special studies are based on the criteria of "sufficiently active" and "well-defined" (Hart, 1988).

GOOSE LAKE FAULT

Do not zone for special studies traces of the Goose Lake fault. This fault is neither sufficiently active nor well-defined.

DAVIS CREEK FAULT ZONE

Do not zone for special studies traces of the Davis Creek fault. Traces of the Davis Creek fault zone are moderately well-defined but lack evidence of Holocene displacement.

FITZHUGH CREEK FAULT ZONE

Do not zone for special studies traces of the Fitzhugh Creek fault zone. Traces of the Fitzhugh Creek fault zone are locally well-defined, but lack evidence of Holocene displacement.

JESS VALLEY FAULT

Do not zone for special studies traces of the Jess Valley fault. This fault is neither sufficiently active nor well defined.

ADDITIONAL FAULTS IN STUDY AREA

Do not zone additional faults in the study area mapped by Gay and Aune (1958), CDWR (1963), and Lydon (1969). These faults are neither sufficiently active nor well-defined.

Reviewed and recommendations approved. Earl W. Hart CEG #935 12/4/90

William A. Bryant

William A. Bryant
Associated Geologist
R.G. #3717
November 26, 1990

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